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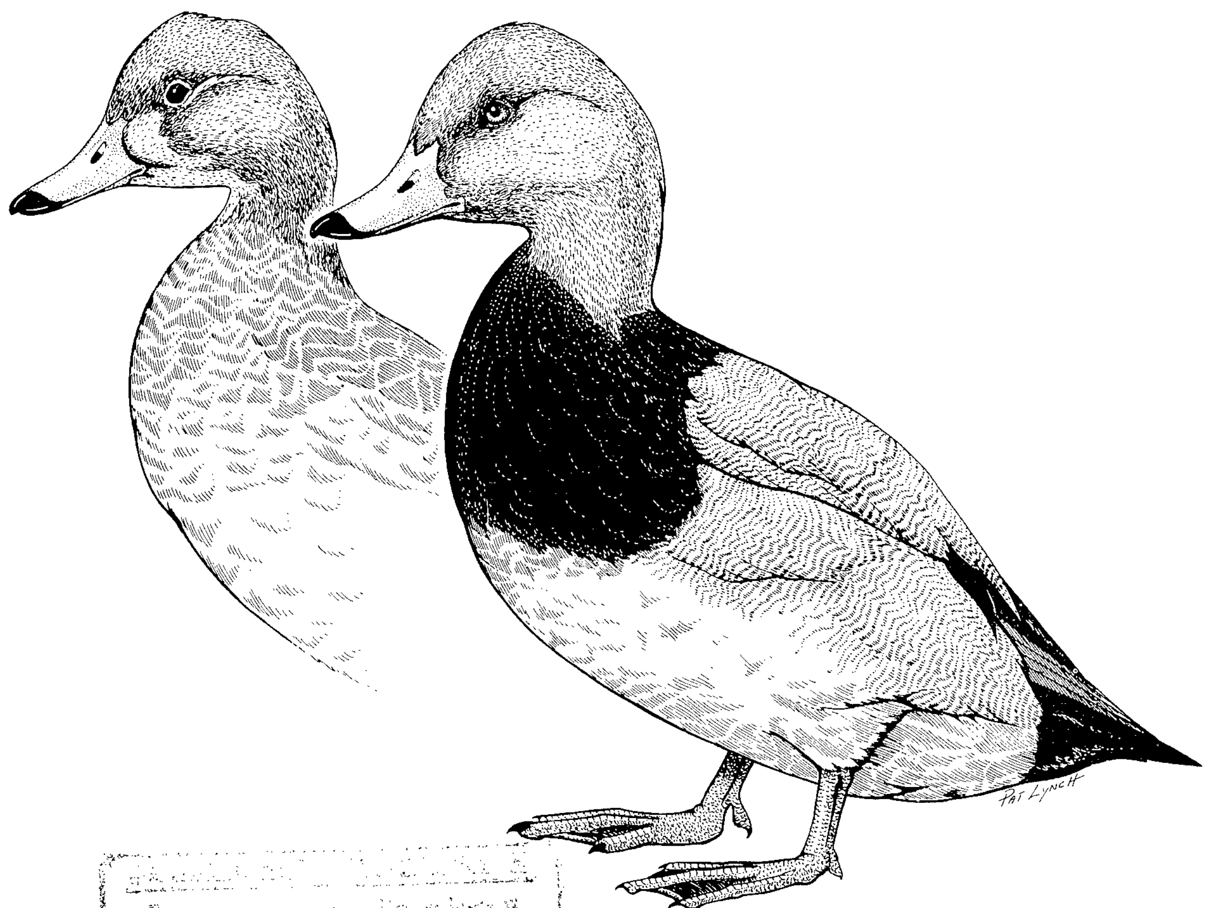
SEPTEMBER 1983

HABITAT SUITABILITY INDEX MODELS: REDHEAD (WINTERING)



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September 1983

HABITAT SUITABILITY INDEX MODELS: REDHEAD (WINTERING)

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PREFACE

The habitat suitability index (HSI) model in this report on the redhead is intended for use in impact assessment and habitat management. The model was developed from a review and synthesis of existing information and is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat). Assumptions involved in developing the HSI model and guidelines for model applications, including methods for measuring model variables, are described.

This model is a hypothesis of species-habitat relationships, not a statement of proven cause and effect relationships. The model has not been field-tested. For this reason, the U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help increase the utility and effectiveness of this habitat-based approach to fish and wildlife management. Please send any comments and suggestions you may have on the HSI model to:

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CONTENTS

ACKNOWLEDGMENTS

Development of the habitat suitability index model for redhead was reviewed and constructively criticized by William Kiel, King Ranch, Kingsville, Texas; and James Teer, Welder Wildlife Foundation, Sinton, Texas. Thorough evaluations of model structure and functional relationships were provided by personnel of the U.S. Fish and Wildlife Service's National Coastal Ecosystems Team (NCET). Nicholas Funicelli served as project officer at NCET. Supportive narrative and model reviews were also provided by Regional personnel of the U.S. Fish and Wildlife Service, including Donald Meineke, Thomas Michot, and Allan Mueller. Funding for model development and publication was provided by the U.S. Fish and Wildlife Service.

REDHEAD (*Aythya americana*)

INTRODUCTION

The redhead is a North American waterfowl species with economic as well as ecological importance. It is highly desired by hunters. Retrieved redhead kill in the United States averaged 143,000 birds during the three waterfowl seasons from 1975 to 1977 (U.S. Department of the Interior 1981a, 1981b). Populations on the principal breeding grounds of the redhead--the prairie and parkland region of south-central Canada and north-central United States--averaged 710,000 birds from 1955 to 1981 (Bellrose 1976; A. Novara, U.S. Fish and Wildlife Service [USFWS], Jamestown, North Dakota; pers. comm.). Redhead numbers began to decline in the 1960's. Killing redheads became illegal from 1960 to 1963, and strict bag limits were imposed after that (Bellrose 1976). A breeding population low of 387,000 birds occurred in 1963, but prairie populations began to recover after that time. Their numbers peaked in 1980 when 1,146,000 birds were recorded (A. Novara, pers. comm.).

During the fall, over a third of the total redhead population uses the migration corridor that extends from the prairie breeding area to the Texas gulf coast. Another migration corridor extends from the second most important breeding area--the Great Salt Basin--to the Texas coast (Bellrose 1976).

Eighty percent of the North American redhead population censused during winter surveys from 1955 to 1974 was found along the coast of the Gulf of Mexico. The most important wintering area near the gulf is the Laguna Madre of Texas and Mexico. Weller (1964) estimated that about 78% of redheads normally wintered on this lagoon. This model will be based primarily on descriptions of wintering habitat found in and around the Laguna Madre, but should be applicable to many redhead wintering areas near the Gulf of Mexico.

SPECIFIC HABITAT REQUIREMENTS

Food

Redheads that winter near the Gulf of Mexico feed primarily on the rhizomatous portion of shoalgrass (*Halodule wrightii*) (Heit 1948; Singleton 1953; Stieglitz 1966; Lynch 1967; Koenig 1969; McMahan 1970; Cornelius 1977; Saunders and Saunders 1981). This attached marine spermatophyte is the dominant seagrass of the Laguna Madre and is extensively distributed in other areas of the gulf coast from Florida (Phillips 1960; Stieglitz 1966) to the Yucatan (Saunders and Saunders 1981) in zones of mixohaline to hyperhaline water. Widgeongrass (*Ruppia maritima*) is readily consumed, but usually is not found over large areas as is shoalgrass. Small amounts of manateegrass (*Cymodocea filiformis*) may also be eaten (McMahan 1970; Cornelius 1977). Redhead food in freshwater wetlands--sites that are used primarily as sources of dietary

water--consists of submerged vegetation including Chara spp. (G. Unland, USFWS, Rio Hondo, Texas; pers. comm.).

Some animal foods and quartzose sand adhere to shoalgrass rhizomes and may be consumed incidentally (Koenig 1969; Cornelius 1975). About 6% of the redhead's winter diet, by volume, may be animal matter (S. March, Texas Oil & Gas Corp.; pers. comm.). This animal matter consists of living snails, clams, and immature crabs, items that supply calcium and amino acid (McMahan 1970; S. March, pers. comm.). Fossil shells that probably function as grit are eaten by redheads on the Laguna Madre (McMahan 1968). Redhead feed throughout the day, but feeding activities peak at twilight and before sunrise.

As mentioned above, shoalgrass is the main food of the redhead on its wintering grounds. Shoalgrass grows in estuarine wetlands with water salinities of 4-60 parts per thousand (ppt) (optimum 25-50 ppt) and depth 0.1-2.5 m (0.3-8.2 ft) with an optimum of 0.5-1.5 m (1.6-4.9 ft) (Simmons 1957; McMahan 1965; Stieglitz 1966). Shoalgrass produces more rhizomatous growth in water of low to moderate turbidity. It does not grow in areas subject to severe wave action. Shoalgrass grows in bottom sediments composed of sand, clay-sand, clay-silt, sand-silt, and shell, but not in soupy organic, heavily silted, or rocky soils (Simmons 1957). Other complex and interrelated variables influencing the distribution and productivity of shoalgrass (Conover 1964) include water pollution (S. Cornelius, privately employed, Mountain View, Missouri; pers. comm.), epiphytism, and parasitism by other marine organisms.

Growth of shoalgrass and other plants in Texas lagoons appeared to be correlated with illumination maxima rather than thermal maxima during 1957 and 1958 (Conover 1964). High turbidity (up to 75% attenuation of light at 1 m or 3.3 ft) and settling of clay particles on leaf surfaces likely contributed to the onset of dormancy in shoalgrass growth during the winter (Conover 1964). Although turbidity shows both seasonal and diurnal fluctuations under natural conditions, disturbances that cause high turbidity levels for more than 1 week during the peak growing season (April to October) will eliminate shoalgrass (Conover 1964).

Cornelius (1975) believed that the abundance of shoalgrass is much less important to redheads than its presence under conditions that allow easy extraction of the rhizomes. The most heavily used feeding areas in the Laguna Madre in 1974 and 1975 were shallow, low turbidity areas with sandy bottom soils where the shoalgrass was short, highly rhizomatous, relatively sparse, and of a higher protein content than shoalgrass from deeper water areas (Cornelius 1975). However, 1974 and 1975 were relatively wet years; under average conditions, redheads may feed mostly in deeper areas where shoalgrass is more abundant (Saunders and Saunders 1981), or they may show better distribution throughout the lagoon (W. Kiel, King Ranch, Kingsville, Texas; pers. comm.).

Water

Redheads are able to excrete salts through exceptionally large salt glands. They probably obtain some metabolic water from the plant foods ingested. Acting together, these two factors may allow redheads to spend the entire winter in water near or at sea salinity (S. Cornelius and G. Unland,

deltas, becomes euhaline. This may be a dilution process because some lagoons become hyperhaline (Skud and Wilson 1960) within a few years after connections with the sea are lost through sand deposition. Heavy rains and runoff from inland areas, however, may dilute some lagoons to below sea strength. Such dilution may alter the composition or distribution of seagrass beds and decrease habitat quality for wintering redhead. On bays, the freshening influence of large riverine inflows may extend several kilometers out to sea.

Disturbance. Disturbance is likely the key factor governing present distribution of wintering redheads in coastal lagoons and bays on the Gulf of Mexico (S. Cornelius, pers. comm.). During most years prior to 1960, feeding flocks of redheads were well distributed throughout the Laguna Madre, Texas (S. Cornelius, pers. comm.). Construction and use of the Intercoastal Waterway have since caused redheads to shift to the less accessible areas of the lagoon.

Human activities have drastically altered hydrology of gulf lagoons (Simmons 1957; Breuer 1962; Chapman 1967; Cornelius, unpubl.). Construction of ship canals and waterways through lagoons and their associated barrier islands has created permanent connections with the sea. The effects of these connections may not influence the hydrology of more distant bays within the lagoons where mixing of sea- and freshwater is slow or difficult (W. Kiel, pers. comm.). Spoil banks have caused differences in salinity and water depth by physically blocking water from winds and currents. High turbidity around canals and waterways is common because of vessel traffic and regularly scheduled maintenance operations. Some lagoons have no continuous inflow of freshwater from inland drainage systems. In these, the wetland zones vary from euhaline to hyperhaline, with halinity reaching levels that may damage the plant and animal community about once every 5-10 years (Saunders and Saunders 1981). Other lagoons have major streams or rivers entering them, but most of the traditional freshwater inflow has been lost to diversion or retention by upstream irrigation projects. In those lagoons, inflows may be restricted to irrigation wastewater.

McMahan (1968) found manateegrass less salt tolerant than shoalgrass and postulated its increase as greater amounts of seawater entered the hyperhaline Laguna Madre through human-made waterways. Cornelius (1977) stated that such an increase should be viewed critically, even if redheads were able to broaden their food intake to include manateegrass, because the changes would reflect significant and possibly detrimental effects on the lagoon's seasonal environment.

More serious than changes in the species composition of the lagoon's benthic flora is the increase in unvegetated bottom. Cornelius (unpubl.) found that unvegetated bottom had increased from 8,000 ha (19,768 acres) in 1965 to 19,500 ha (48,184 acres) in 1974 in the Lower Laguna Madre, Texas. He thought spoil dumping, agricultural wastewater contamination, and shoreline development were the major causes of this phenomenon, but stressed the difficulty of assigning a direct causal relationship to any single factor.

Inland freshwater wetlands in the redhead's wintering range have also been impacted by human activities. Many have been severely degraded by saltwater intrusion from irrigation practices and brine discharges from the oil and gas industry. In some cases, the waters have become totally saturated

with salts. Construction of reservoirs has partly compensated for this loss of natural freshwater drinking areas (S. Cornelius, pers. comm.).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

This model to evaluate habitat suitability was developed from information gathered in the Texas coastal lagoons where the majority of redheads winter. It should also be applicable to most coastal bays and lagoons along the Gulf of Mexico.

Season. Redheads occupy their wintering grounds along the Gulf of Mexico from October through February.

Cover types. The redhead uses the estuarine, subtidal habitat classes of Cowardin et al. (1979) on its wintering grounds.

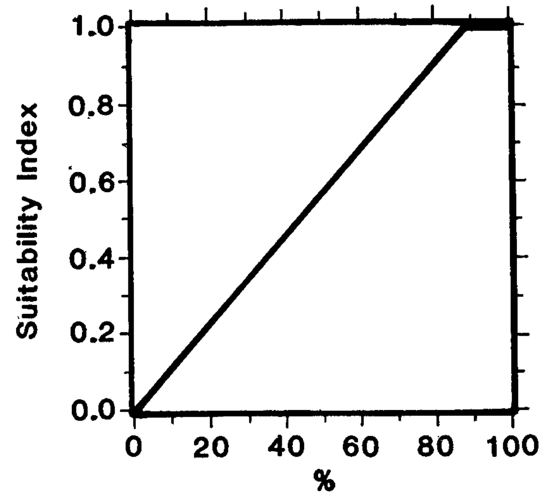
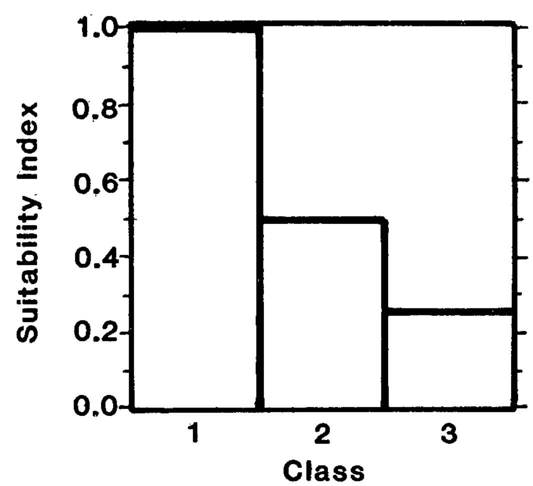
Verification level. The model was reviewed by the following wildlife biologists: William Kiel, King Ranch, Kingsville, Texas; and James Teer, Welder Wildlife Foundation, Sinton, Texas. Although their comments have been incorporated when possible, the authors are responsible for the final version of the model. The model has not been field-tested.

Model Description

Overview. A model consisting of a single life requisite component, food, was developed to evaluate wintering redhead habitat suitability. The study area for wintering redheads is defined in this model as estuarine open water (less than 10% canopy cover of emergent vegetation) less than 5.0 m (16.4 ft) in depth. The relationships among the habitat variables, life requisite component, and study area HSI are illustrated in Figure 1.

Cover and water life requisite components are not included in the HSI model. It is assumed that feeding areas can serve as loafing sites and that a cover component is not necessary. A source of dietary water outside of the estuarine study area (i.e., lacustrine, palustrine, or riverine wetlands) becomes important only during drought years when the study area becomes extremely hyperhaline (i.e., greater than 60 ppt). Estuarine areas in the Gulf of Mexico south of Corpus Christi, Texas, tend to become extremely hyperhaline 1 out of 10 years, on the average. Although salinity and distance from the study area probably affect the suitability of the alternative dietary water sources, no specific data on the magnitude of these effects exist. Therefore, the HSI of a study area with an alternative water source within 20.0 km (12.4 mi) is assumed to be equal to the value of the food component index (CI). The suitability of a site for wintering redheads should decrease if no alternative water source exists within the distance individuals will fly to obtain it. The food CI is multiplied by a constant of 0.9 if no freshwater source exists within 20 km of the study area to reflect this decrease in suitability. This constant was derived by examining a hypothetical situation in which a study area has the optimal value for the food component, but no available freshwater. Over a 10-year period, this area could support the high density of individuals associated with an optimal HSI value (1.0) for 9 years.

Habitat Variable			Suitability Graph

Habitat	Variable		Suitability Graph
E	V_1	Percentage of study area supporting growth of shoalgrass and/or widgeongrass.	
E	V_2	Percentage of total shoalgrass and/or widgeongrass in each of three depth classes. 1) $\leq$ 1 m. 2) 1-2 m. 3) > 2 m. Note: The percentage in each class, expressed as a decimal, becomes the weighting factor (W) for that class. Calculate SI_{V_2} as follows: $SI_{V_2} = 1.0W_1 + 0.5W_2 + 0.25W_3$	

Habitat	Variable		Suitability Graph
E	V_3	Human disturbance to feeding area.	

Human disturbance to feeding area.

1) None to light.
2) Moderate.
3) Heavy.
4) Limiting.

Note: The following calculations are necessary to determine SI_{V_3}:

1) Calculate the disturbance value for each depth class. The constant (C) used in the following equations varies with depth class (see Table 1). The percentage of the depth class in each disturbance class (1, 2, 3, and 4), expressed as a decimal, becomes the weighting factor (W) that is multiplied by the SI for the disturbance class.

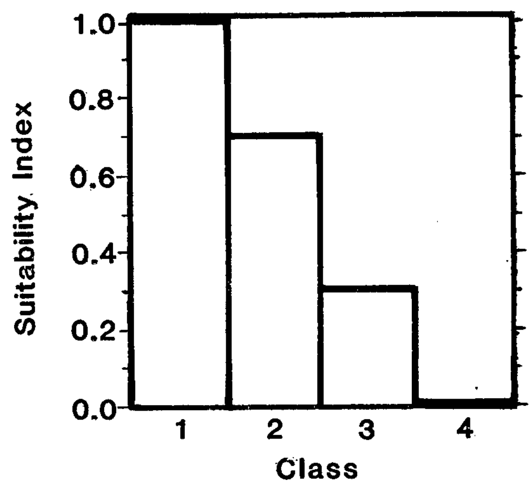
   Depth class 1 (DC_1) = $C(1.0W_1 + 0.7W_2 + 0.3W_3 + 0.0W_4)$

   Depth class 2 (DC_2) = $C(1.0W_1 + 0.7W_2 + 0.3W_3 + 0.0W_4)$

   Depth class 3 (DC_3) = $C(1.0W_1 + 0.7W_2 + 0.3W_3 + 0.0W_4)$

2) Sum the depth class disturbance values.

   $SI_{V_3} = DC_1 + DC_2 + DC_3$



Sample data sets representing a range of habitat suitabilities for wintering redheads were generated. Results obtained when the HSI model was applied to these sets appear in Table 3. Although the data sets are hypothetical, the authors believe that the HSI values generated reflect the relative potential of the habitats to support wintering redheads.

Table 3. Calculations of suitability indices (SI), component indices (CI), and habitat suitability indices (HSI) for three sample data sets using the wintering redhead HSI model variables (V) and equations. All areas except that represented by data set 3 have a source of dietary water within 20.0 km (12.4 mi).

Model component	Data set 1		Data set 2		Data set 3	
	Data	SI	Data	SI	Data	SI
V_1	50%	0.60	20%	0.25	90%	1.00
V_2	Class 1-30% Class 2-70%	0.65	Class 2-100%	0.50	Class 1-10% Class 2-20% Class 3-70%	0.28
V_3	Class 1 to entire area	1.0	Class 2 to entire area	0.70	Class 2 to entire area	0.70
CI_F	0.79		0.49		0.61	
HSI	0.79		0.49		0.55	

Field Use of Model

Habitat measurements needed to apply the wintering redhead HSI can be obtained in the field or from available materials, including maps and aerial photographs. Variables may be estimated to reduce the time and effort required to apply the model, but use of subjective estimates will adversely affect the consistency of model outputs. Appropriate documentation should be provided with the data to insure that decisionmakers are aware of the quality of data used in HSI determinations. Suggested methods for measuring model variables are described in Table 4.

Interpreting Model Outputs

A wintering redhead HSI determined by this model reflects a habitat's potential to support redheads. No relationship between redhead population numbers and the HSI value may be evident because populations may be controlled by nonhabitat factors (e.g., predation, competition) excluded from the model. Correct use of the model involves comparisons of (1) the habitat's potential to support wintering redheads at two points in time, or (2) the potential of two different habitats to support wintering redheads at the same point in time.

Table 4. Suggested techniques for measuring habitat variables included in the wintering redhead HSI model.

Habitat variable	Techniques
V_1	The percentage of the study area supporting growth of shoalgrass/widgeongrass can be obtained from low altitude aerial photographs or existing vegetation maps. Transect sampling by small watercraft from September to October is also possible.
V_2	The distribution of shoalgrass/widgeongrass within the described depth classes can be determined with the use of depth contour maps or through transect sampling of water depth. Sampling should be done at mean low tide.
V_3	The level of human disturbance to redhead feeding habitat can be determined by discussion with biologists or game wardens familiar with the study area or from recreational and hunting records.

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

A review and synthesis of existing information were used to develop a habitat model for redhead (Aythya americana). The model is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for redhead wintering habitat along the northern Gulf of Mexico. Habitat suitability indices are designed for use with habitat evaluation procedures previously developed by the U.S. Fish and Wildlife Service. Guidelines for model applications and techniques for estimating model variables are described.

17. Document Analysis a. Descriptors

Mathematical models
Birds

b. Identifiers/Open-Ended Terms

Habitat
Habitat Suitability Index
Redhead
Impact assessment
Habitat management
Aythya americana

c. COSATI Field/Group

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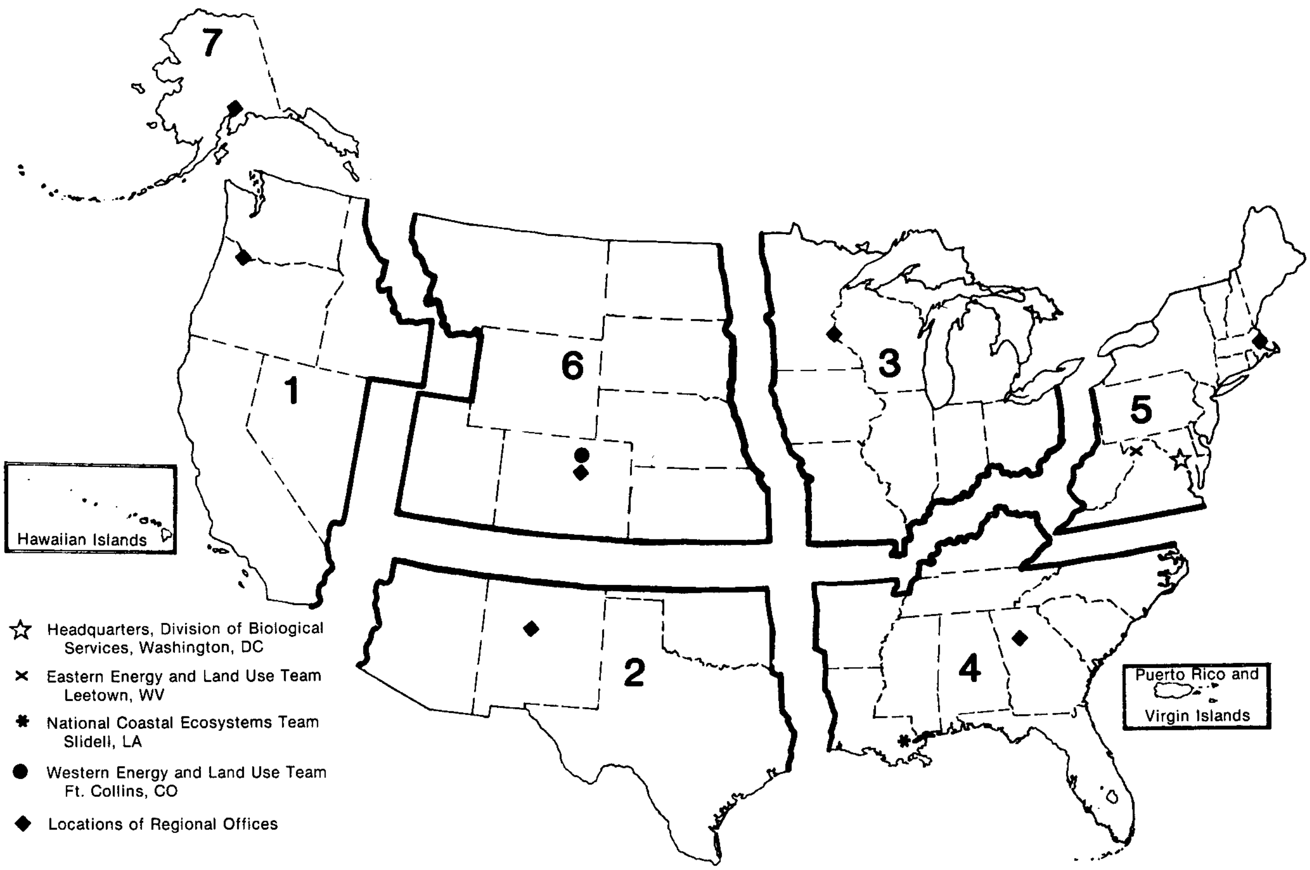

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